

TWR-75703  
ECS SS10964



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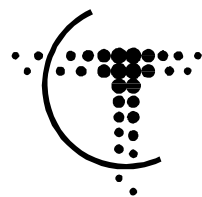


# *Reusable Solid Rocket Motor* **STS-106 Flight Readiness Review/CoFR**

*Motor Set RSRM-75*

**29 August 2000**

*Presented by Terry Boardman*



**Thiokol  
Propulsion™**

**From Cordant Technologies**

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STS-106 (RSRM-75)

# Agenda

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## Flight Readiness Review/CoFR

- 1.0 Previous Flight Assessment—STS-101
- 2.0 Certification Status—**No Constraints**
- 3.0 Changes Since Previous Flight
- 4.0 Configuration Inspection
  - 4.1 As-Built Versus As-Designed and Hardware Status—**No Issues**
  - 4.2 Hardware Changeouts Since ET/SRB Mate Review—**No Issues**
- 5.0 SMRB Nonconformances
- 6.0 Technical Issues/Special Topics—**None**
- 7.0 Major Issues for STS-97 and STS-98—**No Issues**
- 8.0 Readiness Assessment

Backup      LCC and Contingency Temperatures for STS-106



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# Previous Flight Assessment—STS-101

## Disassembly Evaluation Summary—Status of Disassembly Activity

| KSC Operations                                   | LH RSRM  | RH RSRM     | Remarks  |
|--|----------|-------------|--|
| Initial LH/RH SRB viewing                        | Complete | Complete    |  |
| SRB/SRM walkaround assessment                    | Complete | Complete    |  |
| Demate/evaluate aft exit cone (AEC)              | Complete | Complete    |  |
| Remove/evaluate S&A and OPTs                     | Complete | Complete    |  |
| Remove/evaluate nozzle                           | Complete | Complete    | No pocketing erosion   |
| Ship nozzles by truck                            | Complete |             |  |
| Ship S&As  | Complete |             |  |
| Ship AECs by truck                               | Complete |             |  |
| Remove/evaluate stiffener rings/stubs            | Complete | Complete    |  |
| Remove/evaluate igniter                          | Complete | Complete    |  |
| Demate/evaluate field joints/evaluate insulation | Complete | Complete    |  |
| Install handling rings                           | Complete | Complete    |  |
| Ship igniters and stiffener rings by truck       | Complete |             |  |
| Ship segments by rail                            | Complete | Complete    |  |
| Utah Operations                                  |          |             |  |
| Receive nozzles                                  | Complete |             |  |
| Receive S&As                                     | Complete |             |  |
| Disassemble/evaluate nozzle (joint No. 4 and 5)  | Complete | Complete    |  |
| Disassemble/evaluate nozzle (joint No. 2 and 3)  | Complete | Complete    |  |
| Receive AECs                                     | Complete |             |  |
| Disassemble/evaluate S&A                         | Complete | Complete    | IFA STS-101-M-01, RH S&A failed to rotate to "safe" position during disassembly evaluation |
| Washout nozzle phenolics                         | Complete | Complete    |  |
| Washout nozzle AEC phenolics                     | Complete | Complete    |  |
| Receive igniters and stiffener rings             | Complete |             |  |
| Receive segments                                 | Complete | Completed   |  |
| Measure/evaluate aft dome and insulation         | Complete | 18 Sep 2000 |  |



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# Previous Flight Assessment—STS-101

## Disassembly Evaluation Summary—In-Flight Anomaly (IFA) STS-101-M-01 STS-101 RH S&A Device Damaged A-M Actuator Armature Assembly (Ref. PAS DR4-5/315)

Status: Closed at PRCB on 6 Jul 2000

### Observation

- D During postflight electrical safing of the RH safe and arm (S&A) device arming monitor (A-M), rotation of the rotor drive train stopped prior to obtaining a SAFE indication
  - D Observed condition only affects S&A rotation
    - D No impact on ability of barrier-booster (B-B) to detect SAFE/ARM status
    - D No impact on pyrotechnic firing circuit
- D A-M manually rotated to SAFE position without mechanical interference
- D Subsequent disassembly showed damage to A-M motor
  - D Scraped and severed wires on motor armature
  - D Short-circuit between motor and A-M housing
  - D Spring washer lying in motor housing

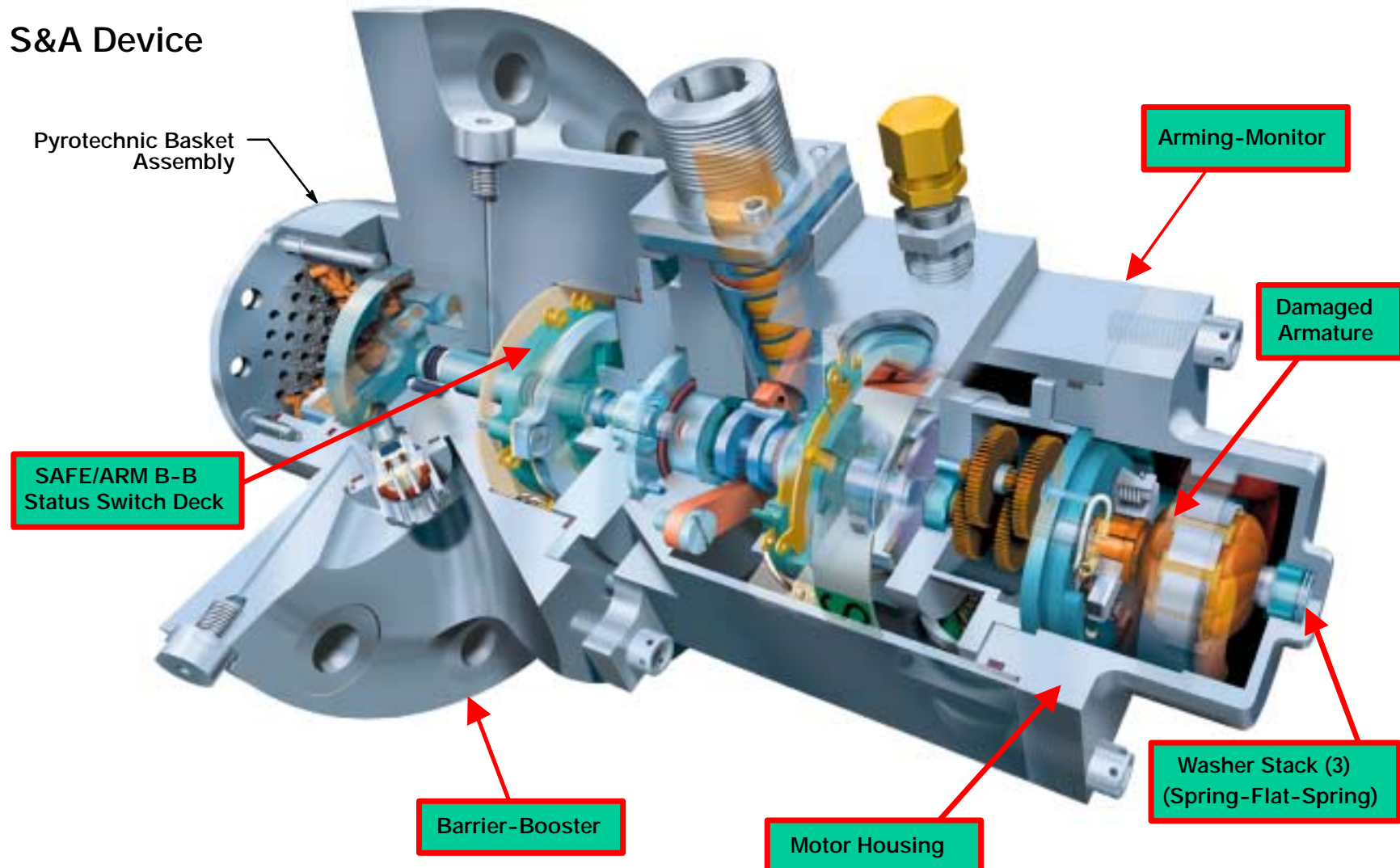
### Flight Concern

- D Potential launch abort due to inability to ARM
- D Potential inability to electrically SAFE in the event of a launch abort (manual SAFE required)

# Previous Flight Assessment—STS-101

## Disassembly Evaluation Summary—IFA STS-101-M-01 (Cont)

### S&A Device

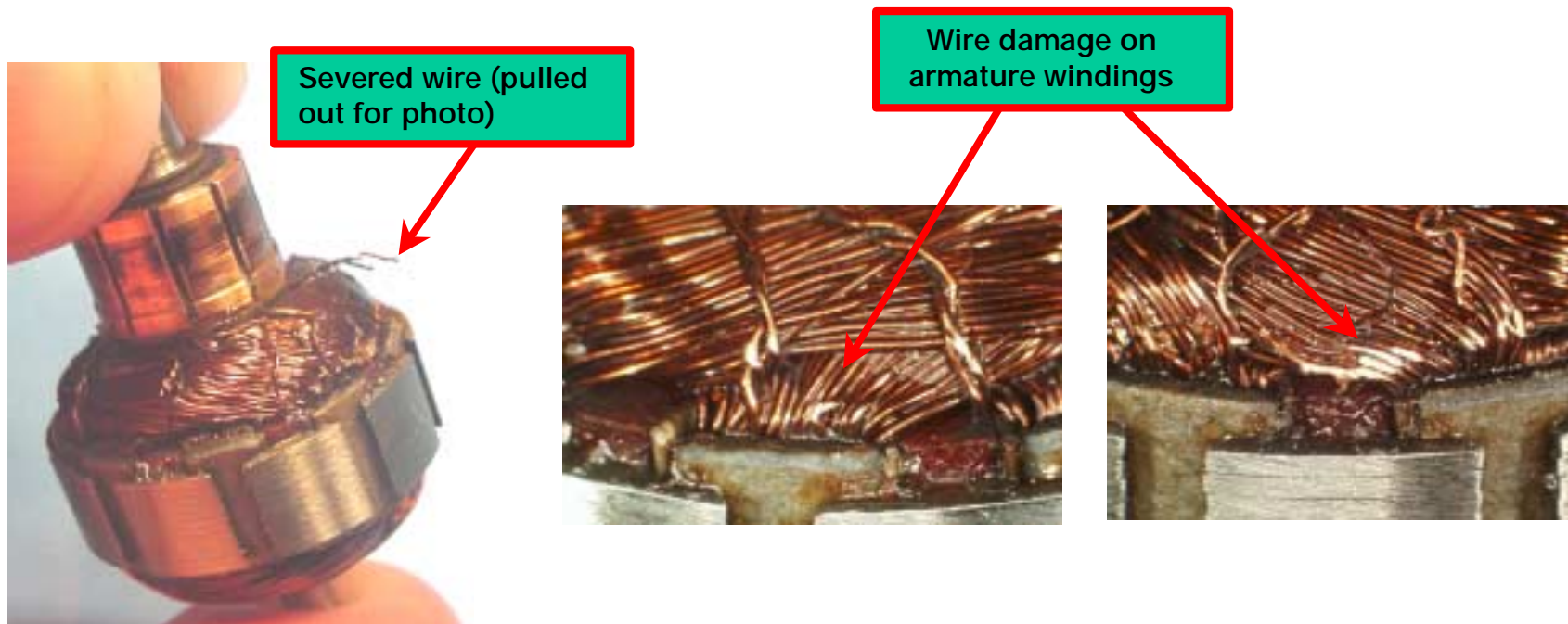


# Previous Flight Assessment—STS-101

## Disassembly Evaluation Summary—IFA STS-101-M-01 (Cont)

### Observations (Cont)

#### D Damaged A-M armature







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# Previous Flight Assessment—STS-101

## Disassembly Evaluation Summary—IFA STS-101-M-01 (Cont)

### Discussion

- D MSFC/Thiokol/Supplier investigation team conducted fault tree analysis to determine cause of failure
  - D Inspection of A-M assembly indicated that A-M motor armature was the only damaged component
  - D Unit was reassembled with new armature and passed all acceptance tests
- D A-M motor armature damage was determined to have been caused by out-of-place spring washer
  - D Displaced spring washer noted during A-M disassembly
  - D Forensic testing identified spring washer (stainless steel) constituents on armature
  - D Failure recreated with intentionally misplaced spring washer
- D Spring washers are used to provide proper armature preload in A-M assembly
  - D Blind installation of motor armature/brush plate assembly allows possibility of displaced spring washer
  - D Armature preload acceptance tests cannot be passed with displaced spring washer
  - D Out-of-sequence armature preload testing was determined to be the root cause quality escape



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1.0-6

# Previous Flight Assessment—STS-101

## Disassembly Evaluation Summary—IFA STS-101-M-01 (Cont)

### Discussion (Cont)

- D Supplier corrective actions have been defined to prevent reoccurrence
- D Definitive radiographic inspection technique developed to verify proper location of washers in A-M assembly

### Flight Rationale

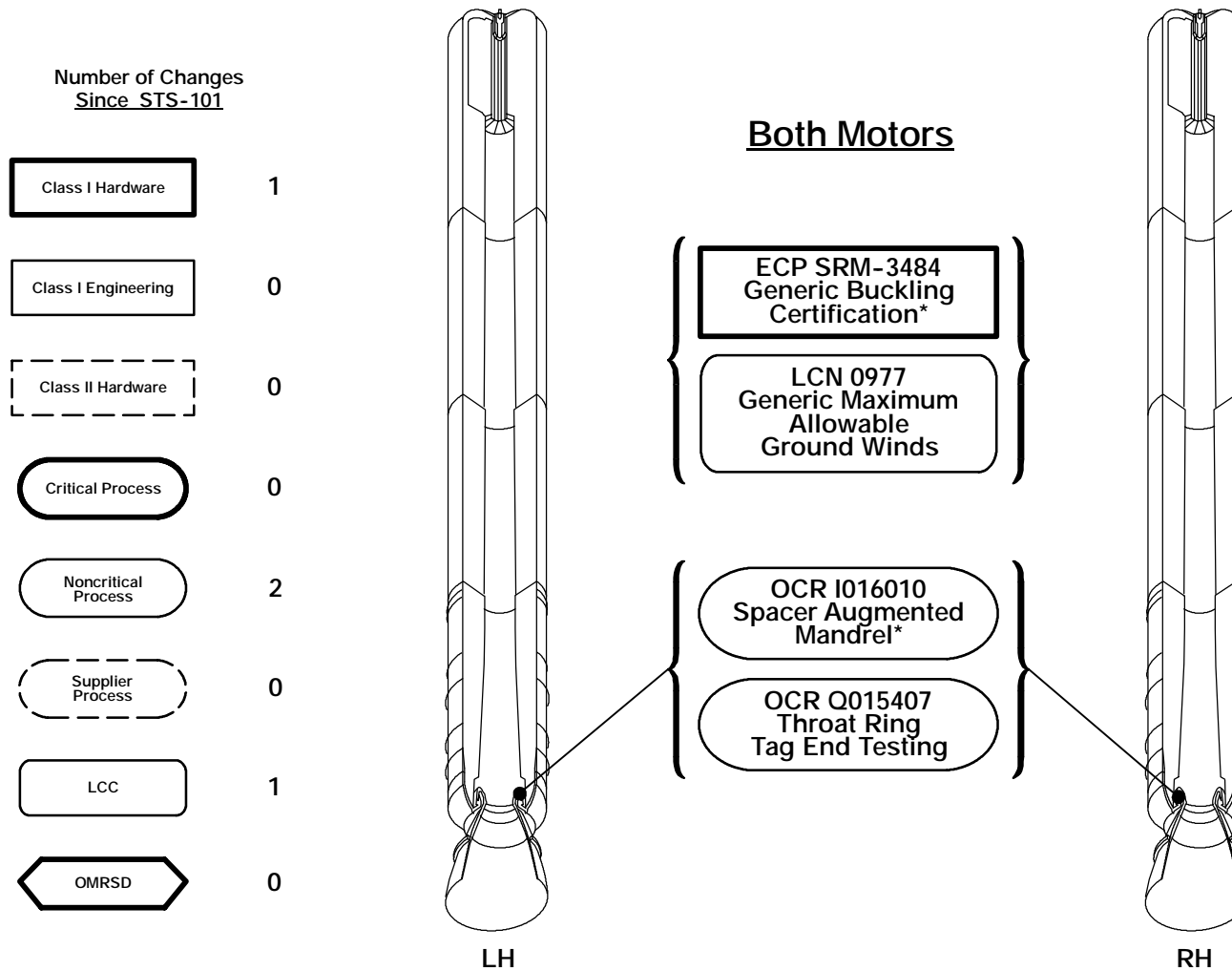
- D Cause of the A-M failure to SAFE is understood and isolated to the A-M assembly—the critical ARM/SAFE status indicating functions of the B-B assembly are not indicted
- D S&A units on STS-106 were removed and replaced with units verified to have proper spring washer stacks via radiographic inspection
- D STS-106 is safe to fly





# Changes Since Previous Flight

## Summary



\*These changes were approved/statused at PRCB



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# Changes Since Previous Flight—Approved

## Class I Hardware and Launch Commit Criteria

ECP SRM-3484, Generic Buckling Certification  
LCN 0977, Generic Maximum Allowable Ground Winds

Criticality: 1

Status: CR S071713 approved at PRCB 1 Jun 2000, LCN 0977 pending PRCB approval

| <u>Change Description</u>   | <u>Reason for Change</u>   | <u>Basis of Verification</u>  |
|---|--|---|
| Increase RSRM prelaunch ground wind requirement from 15 knots from south to 24 knots from south<br><br>Generic certification requires two engineering changes:<br><br>Incorporate axial straightness requirement of $\pm 0.090$ in. for the forward bay of stiffeners<br><br>Incorporate a minimum average wall thickness requirement of 0.474 in. in the forward bay of lightweight stiffeners used in the aft stacking position | Implementation of these requirements will allow removal of exception in NSTS-07700, Vol X, system prelaunch ground wind requirements (24 knots from South) | Ten full-scale buckling tests to failure and nonlinear analysis which correlates to test within five percent verifies that the RSRM generically meets the system prelaunch ground wind requirements with a 1.4 factor of safety |
| Replace flight-specific ground wind LCC limits with NSTS 07700, Vol X, generic limits   | Comply with NSTS-07700, Vol X, requirements following removal of ground winds exception  | Same as above   |



# Changes Since Previous Flight—Approved

## Noncritical Process

OCR I016010, MPCP-0069, Incorporate Spacer-Augmented Mandrel (SAM)

Status: S071527 approved at PRCB on 8 Jan 1998

### Change Description

Incorporate modified phenolic tape wrap mandrel (SAM) for fabricating nozzle throat rings. Inserted 1.9-in. spacer between forward and aft sections of existing mandrel

### Reason for Change

Nozzle pocketing erosion corrective action

Modified mandrel provides increased overstock in aft ID end of the throat ring billet—ply distortions subsequently machined away

SAM implementation is the final corrective action element required to close the STS-79 RH nozzle pocketing issue

### Basis of Verification

Test: Five full-scale test billets fabricated with design of experiments (DOE) combinations of process and material variables affecting rate of cure and degree of ply distortions. Billets were sectioned to verify ply distortions were within overstock region and no additional distortions were introduced by the added material. Material inserts fired successfully in forty-pound charge motors and MNASA-8

Demonstration: FSM-7, FSM-8

SAM throat billet fabricated using qualified materials, processes, equipment, personnel, and facilities. No changes to tape width, outer diameter (OD) overstock thickness, or cure cycle

OCR Q015407, Throat Ring Tag End Fabrication and Testing

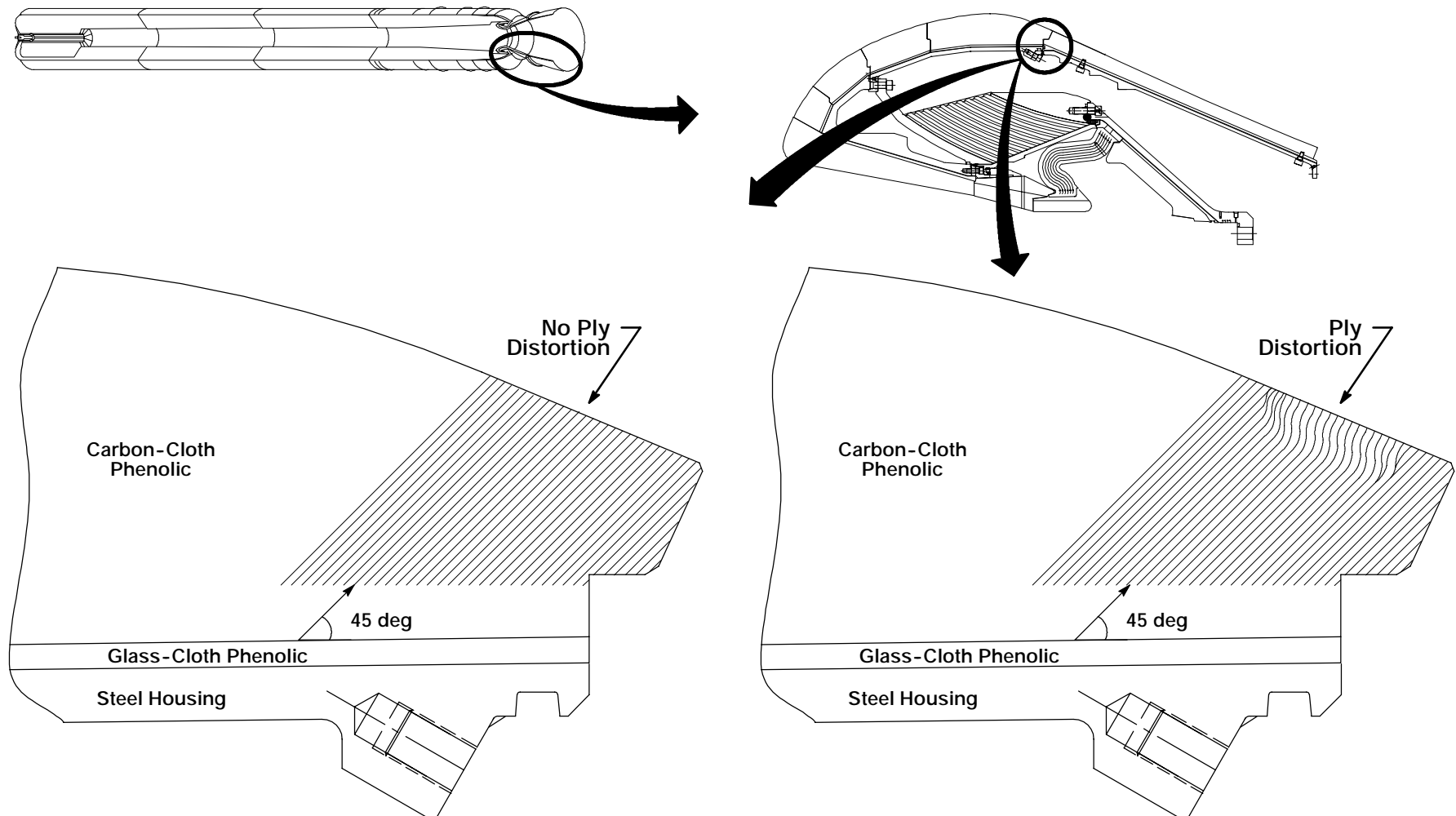
Status: Approved

Fabricate new tag end test specimens from aft end of throat ring billet. Perform standard tag end tests at Thiokol and LHMEI testing

Implementation of SAM provides sufficient material to fabricate tag end specimens from aft end of billet. Aft tag data will compliment data from forward tag end specimens

# Changes Since Previous Flight—Approved

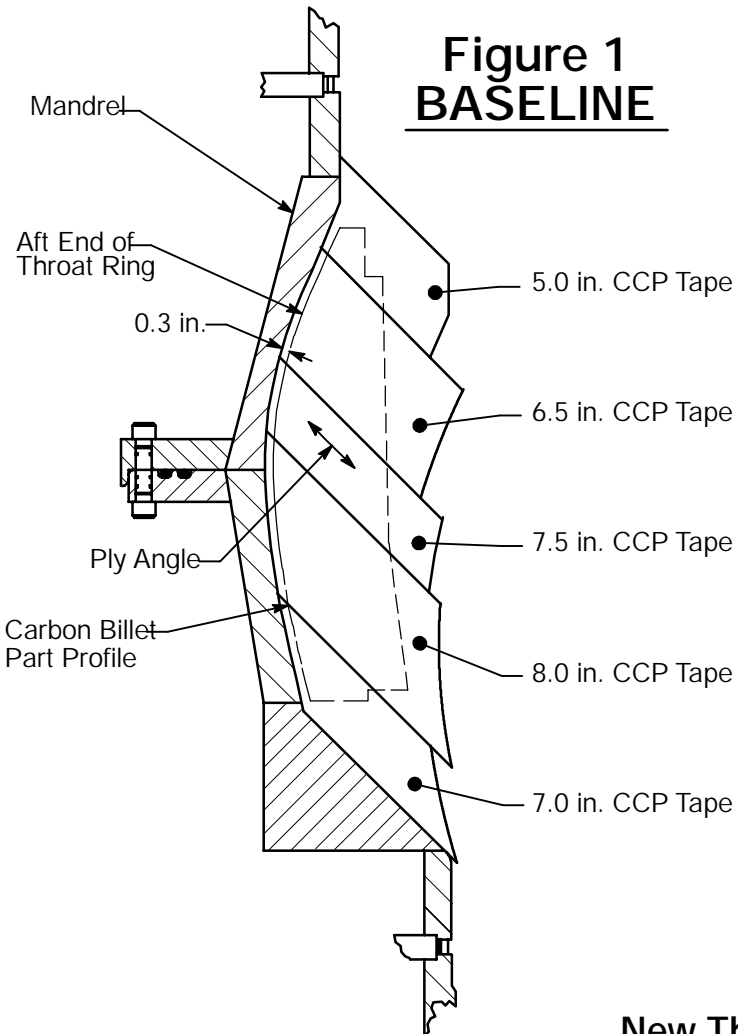
## Noncritical Process, OCR I016010 (Cont)



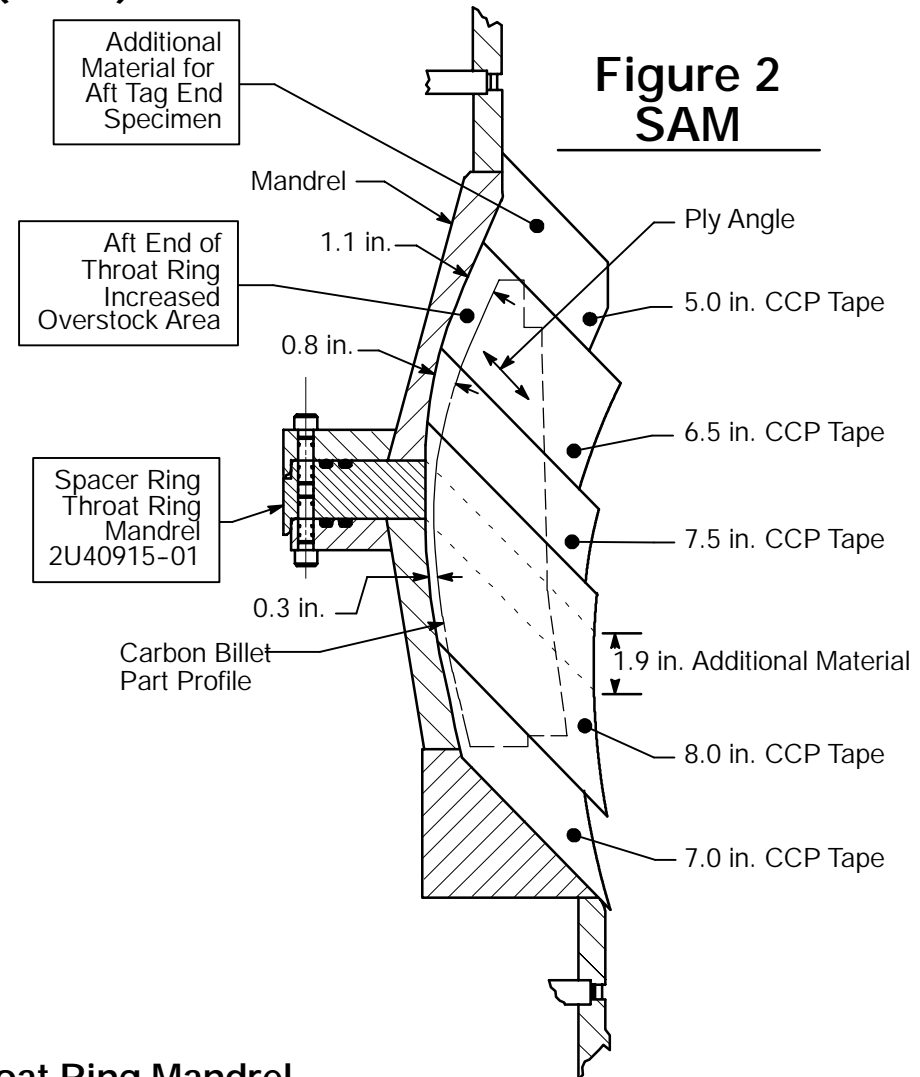
Cross Section of Nozzle and Ply Distortions

# Changes Since Previous Flight—Approved

## Noncritical Process, OCR I016010 (Cont)



**Figure 1**  
**BASELINE**

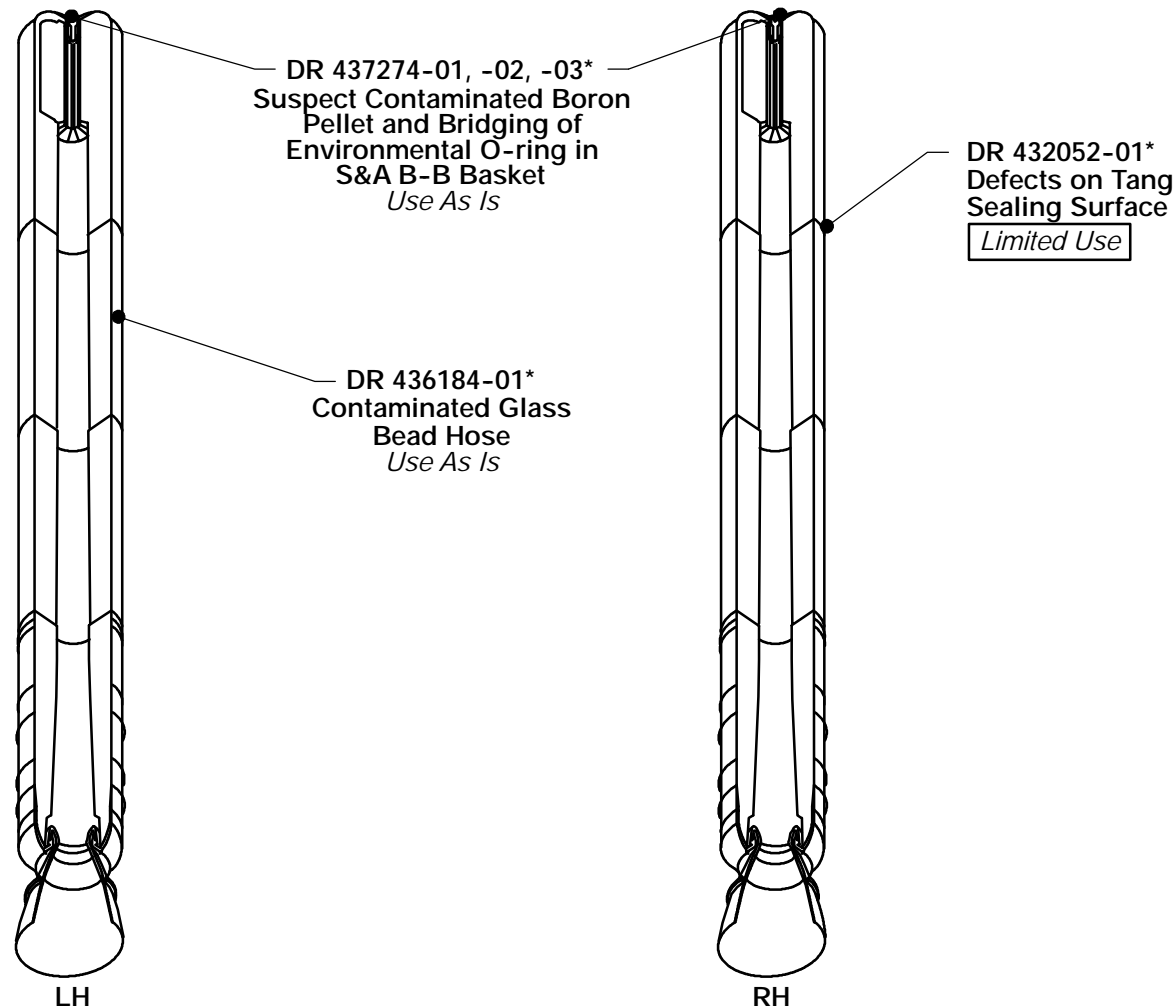


**Figure 2**  
**SAM**

New Throat Ring Mandrel

# SMRB Nonconformances

## Summary

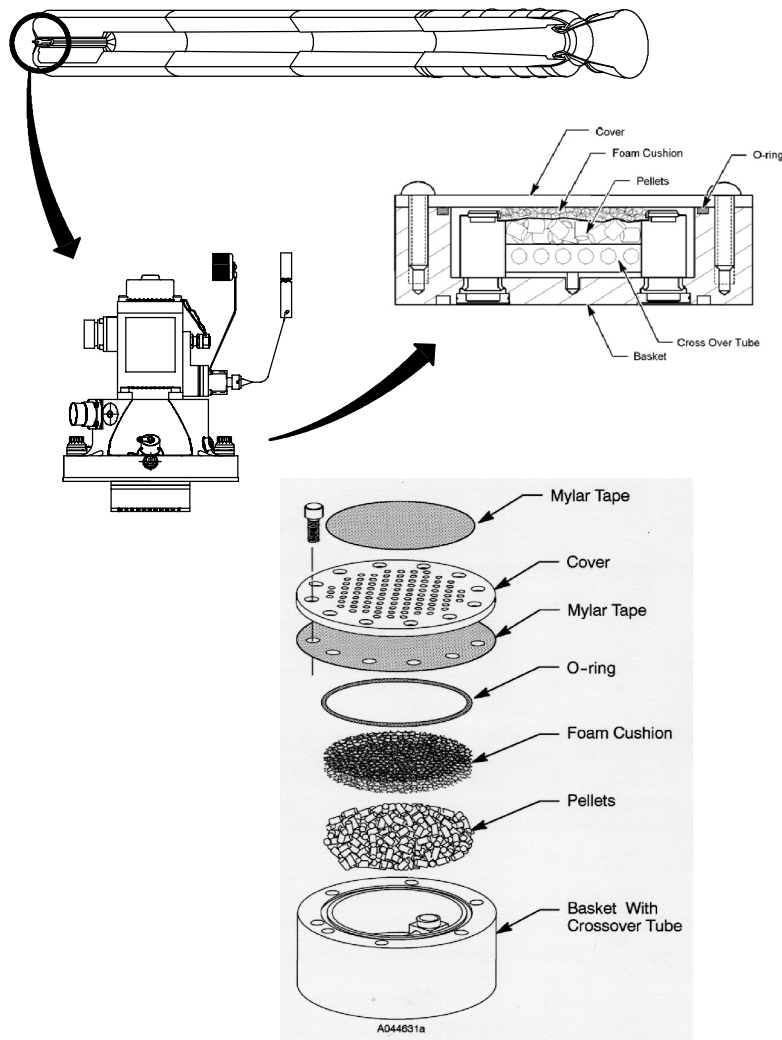


Detailed nonconformance discussions included, unless resulting flight hardware is within family of previous flight experience (\*) or reuse issue only (\*\*)



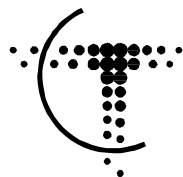
# SMRB Nonconformances

## Summary



### LH/RH Safe and Arm Device—DRs 437274-01, -02

- D Item -01, suspect grease on boron/potassium nitrate ( $\text{BKNO}_3$ ) pellets in barrier-booster (B-B) basket (entire lot) may affect ballistic performance
  - D 87 baskets from lot previously fired with no anomalous results
    - D Includes 34 flight baskets
  - D Four hot-fire tests with worst-case grease contamination show no effect on pellet basket ballistics (heavy grease on multiple pellets)
  - D Hot-fire tests of six other suspect baskets show no effect on ballistics
  - D Energetic material sensitivity tests with worst-case grease contamination (up to 50 percent by weight) show no adverse effect on basket storage or handling safety
- D Item -02, suspect bridging of B-B basket environmental O-ring by foam cushion (entire lot) may compromise moisture environmental barrier
  - D No pressure decay for any internal pressure tested (up to 10 psi)
    - D No visible leakage for pressures up to 50 psi
    - D Failure pressures exceed 350 psi
  - D No vacuum decay for any internal vacuum tested (down to -10 psi)
  - D Requirement is maximum Utah/KSC differential pressure of 4.7 psi
- D Based on extensive testing of grease effects on B-B ballistics and potential for moisture leakage across the O-ring environmental barrier, no effects of either are noted, and STS-106 is safe to fly



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## *STS–106 Readiness Assessment*

*Pending satisfactory completion of normal  
operations flow (per OMRSD), the RSRM hardware  
is ready to support flight for mission*

*STS–106*

*29 August 2000*

*/s/ T. A. Boardman*

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*T. A. Boardman  
RSRM Chief Engineer  
Thiokol*

*/s/ G. C. Alford*

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*G. C. Alford  
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*/s/ S. F. Cash*

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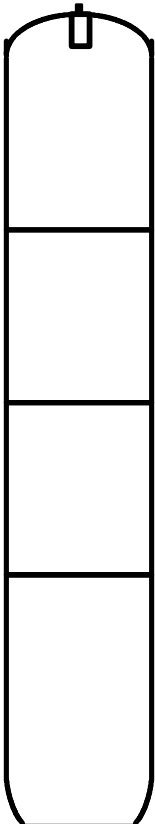


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Backup-1

# Current Flight Predictions

## LCC and Contingency Temperatures for STS-106

|  | <u>Heater Location</u> | <u>LCC</u> | <u>Minimum Allowable Sensor Temperature*</u> |           |
|--|------------------------|------------|--|-----------|
|  |                        |            | <u>LH</u>                                    | <u>RH</u> |
|  | Igniter                | 74_F       | 72_F   | 72_F      |
|  | Forward Field Joint    | 80_F       | 66_F   | 68_F      |
|  | Center Field Joint     | 80_F       | 72_F   | 68_F      |
|  | Aft Field Joint        | 80_F       | 69_F   | 66_F      |
|  | Nozzle-to-Case Joint   | 75_F       | 66_F   | 68_F      |

\*Launch commit criteria (LCC) contingency temperature in the event of heater failure

Note: Calculation includes all standard repair conditions